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NATIONAL DAM SAFETY PROGRAM. TERRACE LAKE DAM (MO 20167), MISSO--ETC(U)
AUG 78 D P GUPTA, B A AINSWORTH, H L CALLAHAN DACW43-78-C-0148
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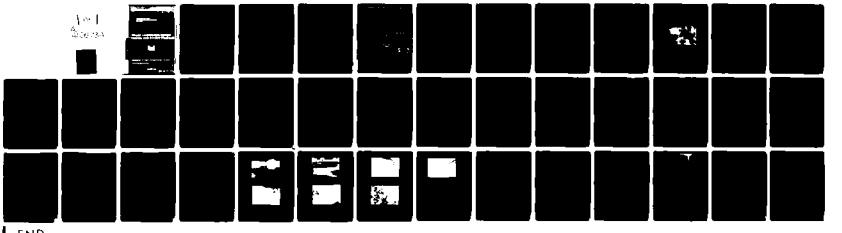

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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MISSOURI-KANSAS CITY BASIN

TERRACE LAKE DAM
JACKSON COUNTY, MISSOURI
MO 20167

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST 1978

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Terrace Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Terrace Lake dam:

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood.
2) Overtopping could result in dam failure.
3) Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division
9 FEB 1979
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer
9 FEB 1979
Date

TERRACE LAKE DAM

JACKSON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20167

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

AUGUST 1978

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Terrace Lake Dam
State Located	Missouri
County Located	Jackson County
Stream	Tributary of Blue River
Date of Inspection	17 August 1978

Terrace Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers failure would threaten the life and property of approximately five families downstream of the dam and would potentially cause appreciable damage to five streets within the estimated damage zone which extends 1/2 mile downstream of the dam.

Our inspection and evaluation indicates the spillway of Terrace Lake Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Terrace Lake Dam is a small size dam with a high hazard potential required by the guidelines to pass from one-half the Probable Maximum Flood (PMF) to the Probable Maximum Flood (PMF). However, considering the high hazard potential to loss of life (five families) and the property downstream of the dam the spillway size should be able to pass the PMF without overtopping the dam. The spillway of Terrace Lake Dam will pass 15 percent of the PMF without overtopping, which is less than the estimated 100-year flood.

Deficiencies visually observed by the inspection team were irregular embankment slopes, seepage, and presence of excessive brush and large trees on the downstream embankment slope. Also, the sloughing of the riprap on the upstream embankment slope has contributed to erosion of the embankment material. Seepage and stability analyses are not available as required by the guidelines for dams having the above size and hazard potential.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to prevent additional vegetal growth on the embankment which could lead to the development of potential safety hazards. A detailed report discussing each of these deficiencies follows.

Dwarka P. Gupta

D.P. Gupta, PE
Missouri E-17479

Bruce A. Ainsworth

Bruce A. Ainsworth, PE
Missouri E-18023

Harry L. Callahan

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
TERRACE LAKE DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Terrace Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furshed by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the valley of a tributary to the Blue River in south-west Jackson County, Missouri (see Plate 1). A roadway has been constructed across the top of the dam. Traffic across the dam is prohibited by locked gates. Topography of the contributing watershed is characterized by rolling hills. Land use consists primarily of residential areas. Topography in the vicinity of the dam is shown on Plate 2.

(2) A concrete spillway is constructed at the south abutment. A 10.2 by 1.6 feet box culvert permits spillway flow to pass under the roadway across the dam. The road across the dam is not a thoroughfare due to locked gates prohibiting traffic.

(3) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in the south-west portion of Jackson County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Grandview, Missouri in Sections 2 and 3 of T47N, R33W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification as assigned by the Corps of Engineers is as follows: The Terrace Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life and serious damage to homes; agricultural, industrial and commercial facilities; and important public utilities, main highways or railroads. For the Terrace Lake Dam, the flood damage zone extends 1/2 mile downstream of the dam. Within the damage zone are five homes and five streets.

e. Ownership. The dam is owned by the Terrace Lake Tract Home Owners Association, Inc., 11100 Kensington, Kansas City, Missouri 64137.

f. Purpose of Dam. The dam forms a 5.5 acre recreational lake.

g. Design and Construction History. Unknown.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation and discharge from the uncontrolled spillway all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 90 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled spillway.

(2) Estimated experienced maximum flood at damsite - unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation -124 cfs (top of dam).

c. Elevation (Feet Above M.S.L.).

(1) Top of dam - 958.0 ± (see Plate 3)

(2) Spillway crest - 956.5

(3) Streambed at centerline of dam - 933 ±

(4) Maximum tailwater - unknown.

d. Reservoir. Length of maximum pool - 700 feet ±

e. Storage (Acre-feet).

(1) Top of dam - 50

(2) Spillway crest - 40

(3) Design Surcharge - not available

f. Reservoir Surface (Acres).

(1) Top of dam - 6.5

(2) Spillway crest - 5.5

g. Dam.

(1) Type - earth embankment

(2) Length - 360 feet

(3) Height - 25 feet

(4) Top width - varies from 16 to 27 feet

(5) Side Slopes - back slope approximately 2H to 1V, front slope unknown (see Plate 4)

(6) Zoning - unknown.

(7) Impervious Core - unknown.

(8) Cutoff - unknown.

(9) Grout curtain - unknown.

h. Diversion and Regulating Tunnel - none.

i. Spillway.

(1) Type - chute (see paragraph 3.1c)

(2) Width of Spillway - 10.2 feet (see paragraph 3.1c)

(3) Crest elevation - 956.5 feet m.s.l.

(4) Gates - none.

(5) Upstream Channel - none.

(6) Downstream Channel - broken limestone.

j. Regulating Outlets - none.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design data was available.

2.2 CONSTRUCTION

No construction data was available.

2.3 OPERATION

No operation records were available.

2.4 EVALUATION

a. Availability. No engineering data was available. In accordance with section 3.6.1 of the "Recommended Guidelines for Safety Inspection of Dams" seepage and stability analyses for appropriate loading conditions should be on file for dams in the High Hazard classification.

b. Adequacy. The engineering data was inadequate to make a detailed assessment of design, construction, and operation.

c. Validity. The engineering data was insufficient to determine the validity of the design, construction, and operation.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Terrace Lake Dam was made on 17 August 1978. The inspection team included professional engineers with experience in dam design and construction, hydrologic - hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. Protection of the upstream embankment slope consists of a 2 to 3 feet high stone masonry wall with rock riprap of widely varying sizes extending from the bottom of the wall into the reservoir. The wall is sloughing and deteriorating at the right abutment due to tree roots. The upstream and downstream slopes are of irregular alignment which appears to be the result of erosion and settlement. The erosion on the upstream face of the embankment appears to be caused by surface runoff and the fluctuation of the lake surface. Settling and cracks were observed along the entire length of the wall on the upstream face with 50 to 60 feet of wall missing near the right abutment resulting in erosion of the embankment material. Excessive growth of trees and brush was observed along the entire length of the downstream embankment slope. The inspection team did not observe any animal burrows on the embankment.

c. Appurtenant Structures. The spillway is a 10.2 by 1.6 feet box culvert with a concrete approach apron beginning 10 feet upstream of the spillway. The spillway appeared in good condition other than some minor spalling. The spillway discharges into a broken limestone channel which is severely overgrown with weeds and small trees. Erosion was observed behind the left spillway training wall, but did not appear serious. Seepage of less than 5 gpm was observed in the discharge channel about 25 feet downstream from the axis of the dam.

d. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir.

e. Downstream Channel. Spillway discharge flows from the spillway to a discharge channel lined with randomly placed limestone. Flow then proceeds to the streambed channel and through culverts under residential streets downstream of the dam. The downstream channel passes through primarily residential area.

3.2 EVALUATION

None of the conditions observed are significant enough to indicate a need for immediate remedial action or a serious potential of failure.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is controlled by rainfall, runoff, evaporation, and capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

The spillway has been lined with concrete, reportedly, in recent years.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

Excessive growth of trees and brush observed on the downstream side of the dam increase the potential for failure and warrant regular monitoring and control.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data was available.

b. Experience Data. The drainage area and lake surface area are developed from USGS Grandview, Missouri Quadrangle Map. The spillway and dam layout drawings in this report are from surveys made during the inspection.

c. Visual Observations.

(1) Concrete spillway and the spillway discharge channel are in good condition. Heavy growth of weeds and small timber in the discharge channel was observed. Because there are no training walls along the discharge channel, flows that exceed the channel capacity would overflow onto the downstream embankment slope and erode the embankment material resulting in a serious potential of failure. The obstructions in the channel would magnify this problem.

(2) To the inspection team's knowledge no drawdown facilities are available to evacuate the pool.

(3) The spillway and outlet channel are located at the south abutment. Spillway discharge may endanger the integrity of the dam.

d. Overtopping Potential. The spillway will not pass the probable maximum flood, which is the spillway design flood recommended by the guidelines, without overtopping. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The existing spillway will pass 15 percent of the probable maximum flood without overtopping the dam. This flood is greater than the 100-year flood estimated by the methodology outlined by the USGS in "Technique for Estimating the Magnitude and Frequency of Missouri Floods". According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood without overtopping. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 1,500 cfs of the total discharge from the reservoir of 1,700 cfs. The overtopping duration is estimated to be 6 hours. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 500 cfs of the total discharge from the reservoir of 830 cfs. The overtopping duration is estimated to be 4 hours.

According to the St. Louis District, Corps of Engineers, the effect from failure of the dam could extend approximately 1/2 mile downstream of the dam. There are five inhabited homes downstream of the dam which could be severely damaged and lives of the inhabitants could be lost should failure of the dam occur.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found.

c. Operating Records. No operational records exist.

d. Post Construction Changes. The dam was capped with 3 to 4 feet of fill contained between two rock walls approximately 13 feet apart for the length of the dam. An asphalt paving surface was placed on the fill. Concrete was placed in the spillway channel to increase the lake level and provide protection for the approach and spillway channels. Details and the dates of the two changes are unavailable.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

The seismic stability of an earth dam is dependent upon a number of factors: The important factors being embankment and foundation materials and shear strengths; abutment materials, conditions, and strength; embankment zoning; and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several items observed during the visual inspection by the inspection team which should be monitored or controlled are sloughing and deterioration of the upstream slope protection, growth of large trees and brush along the downstream face, seepage in the spillway discharge channel, and the irregular slopes on the downstream and upstream faces.

b. Adequacy of Information. Due to the inadequacy of engineering design data, the conclusions in this report were based on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses are required to meet the criteria established by the guidelines.

c. Urgency. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2 could be accomplished now or delayed until observations of this monitoring program and/or the recommendation of a qualified engineer indicate the necessity of action. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure. Presently, immediate action is not considered necessary.

d. Seismic Stability. This dam is located in Seismic Zone 1. Because stability analyses are not available, the seismic stability of the dam cannot be assessed. An assessment of the seismic stability should be included as part of the stability analyses required.

7.2 REMEDIAL MEASURES

a. Alternatives. In order to pass 100 percent of the probable maximum flood without overtopping the dam, the spillway size and/or height of dam should be increased.

b. O&M Maintenance and Procedures. The following O&M maintenance and procedures are recommended:

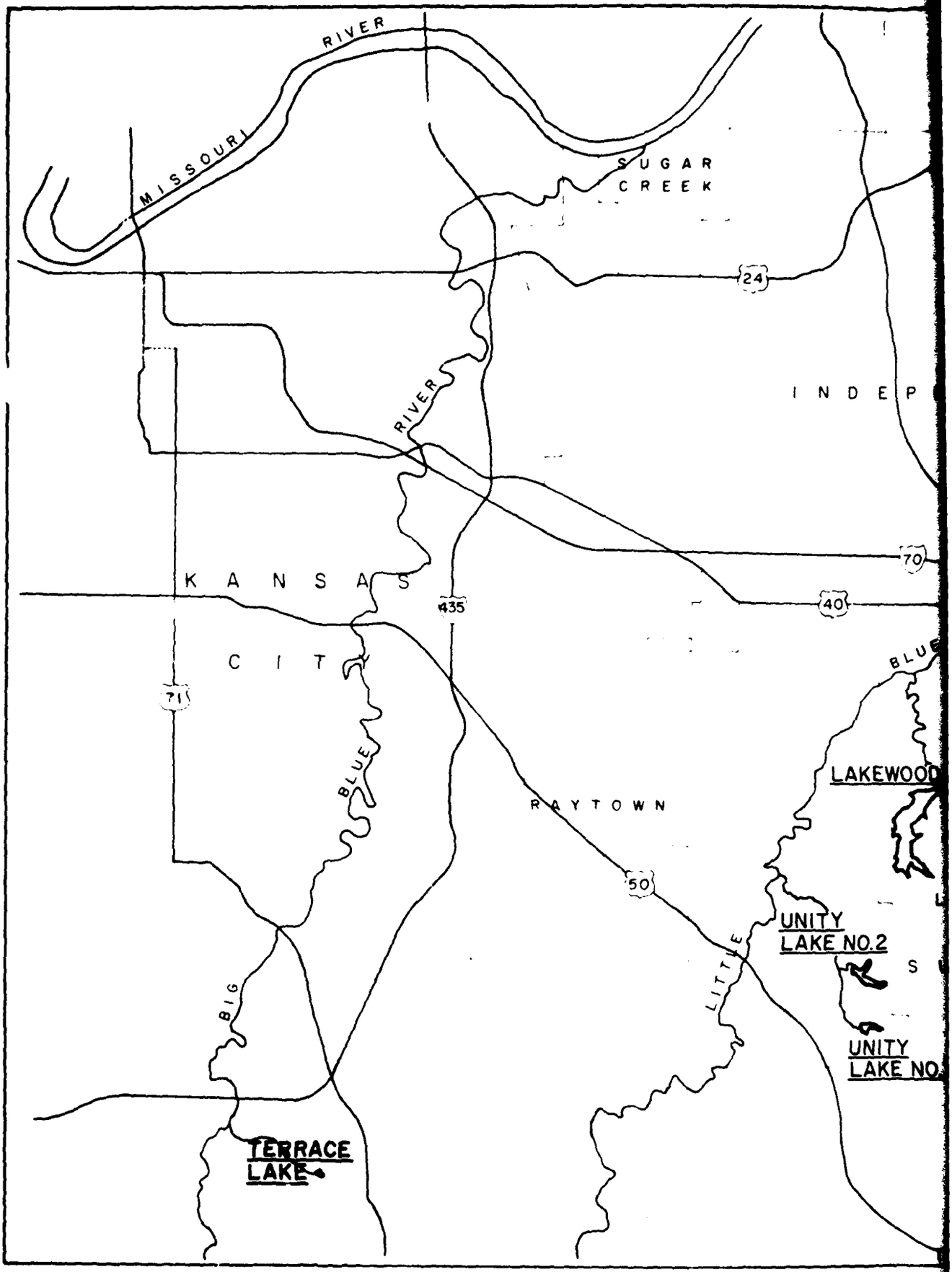
(1) Check the downstream face of the dam periodically for seepage and stability problems. If increased seepage flows are observed or deterioration of the embankment noted, the dam should be inspected and the pending condition evaluated by an engineer experienced in design and construction of earthen dams.

(2) The riprap on the upstream face should be repaired to prevent further erosion of embankment material.

(3) Due to the density and large size of the trees on the downstream slope of the dam, an engineer experienced in the maintenance and design of earthen dams should be retained to determine the method of removal of these trees. The actual removal should be under the supervision of an engineer experienced in the design and construction of earthen dams.

(4) A detailed inspection of the dam should be made at least every year by an engineer experienced in design and construction of dams. More frequent inspections may be required if items of distress are observed other than those already mentioned.

(5) Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams.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LITTLE
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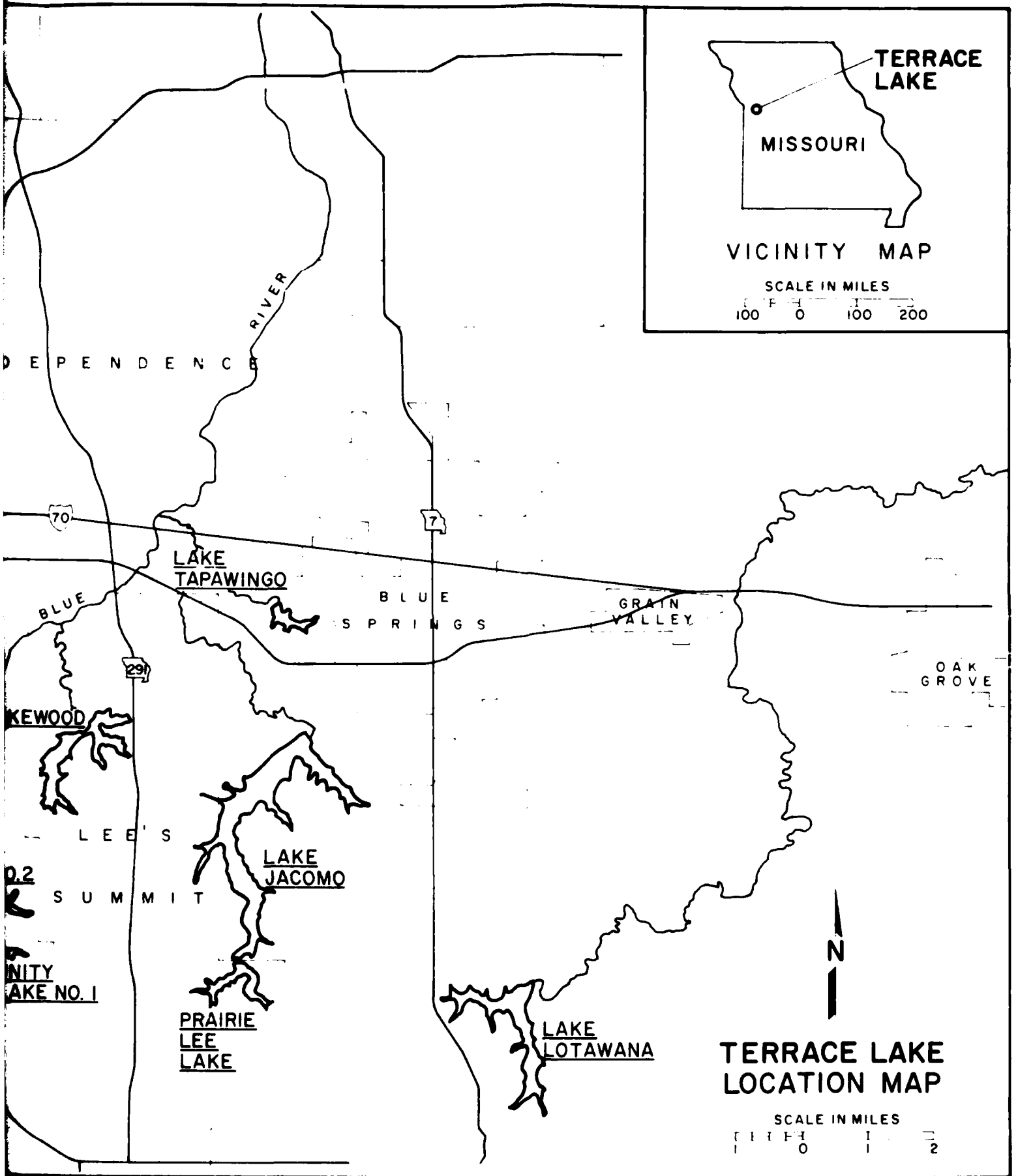
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GRAIN VALLEY
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KEWOOD
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PLATE I

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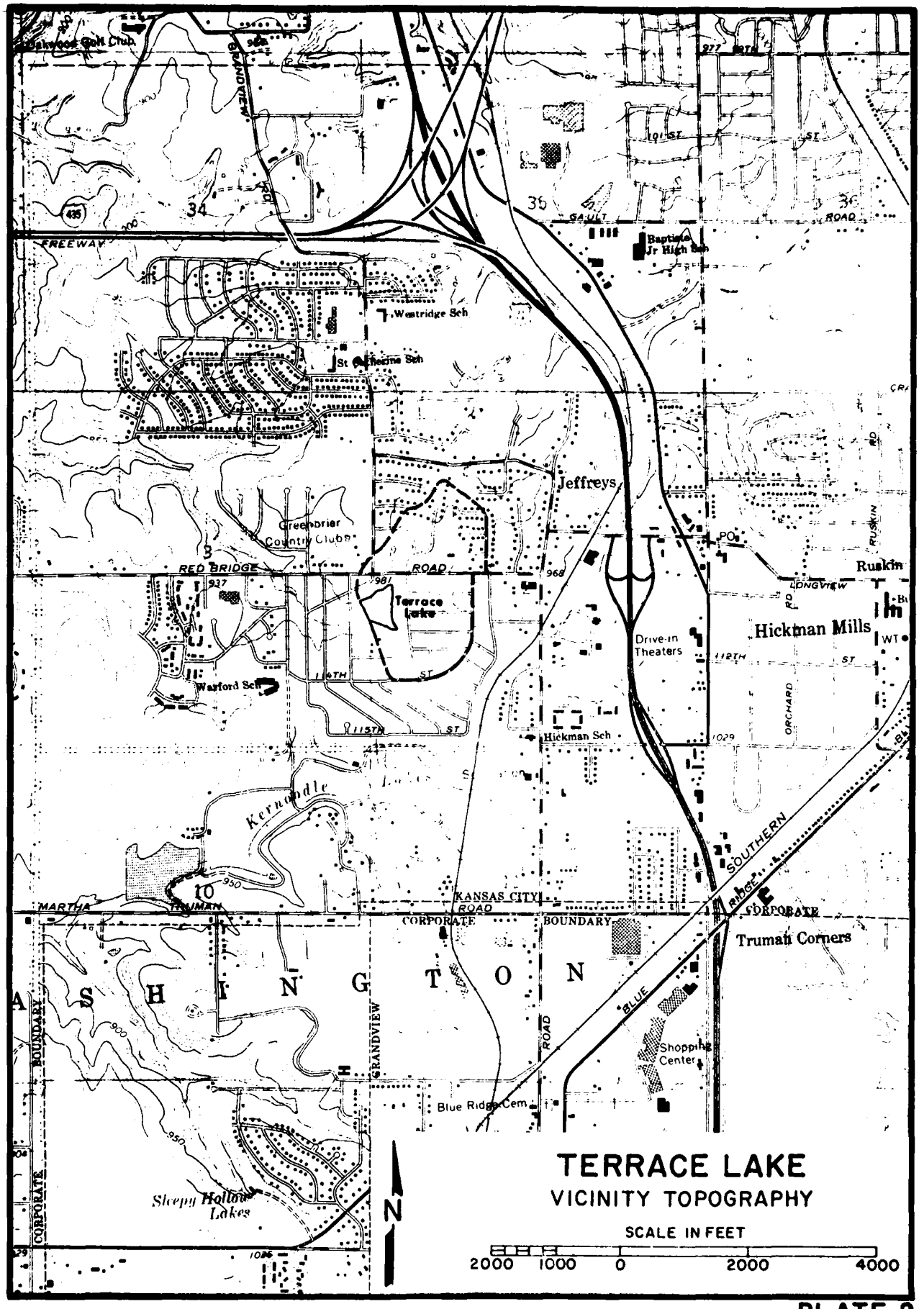
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Hickman Mills
Ruskin
Hickman Sch
Kenwoodle
SOUTHERN
MARTHA TRUMAN ROAD
KANSAS CITY
CORPORATE BOUNDARY
Truman Corners
GRANDVIEW ROAD
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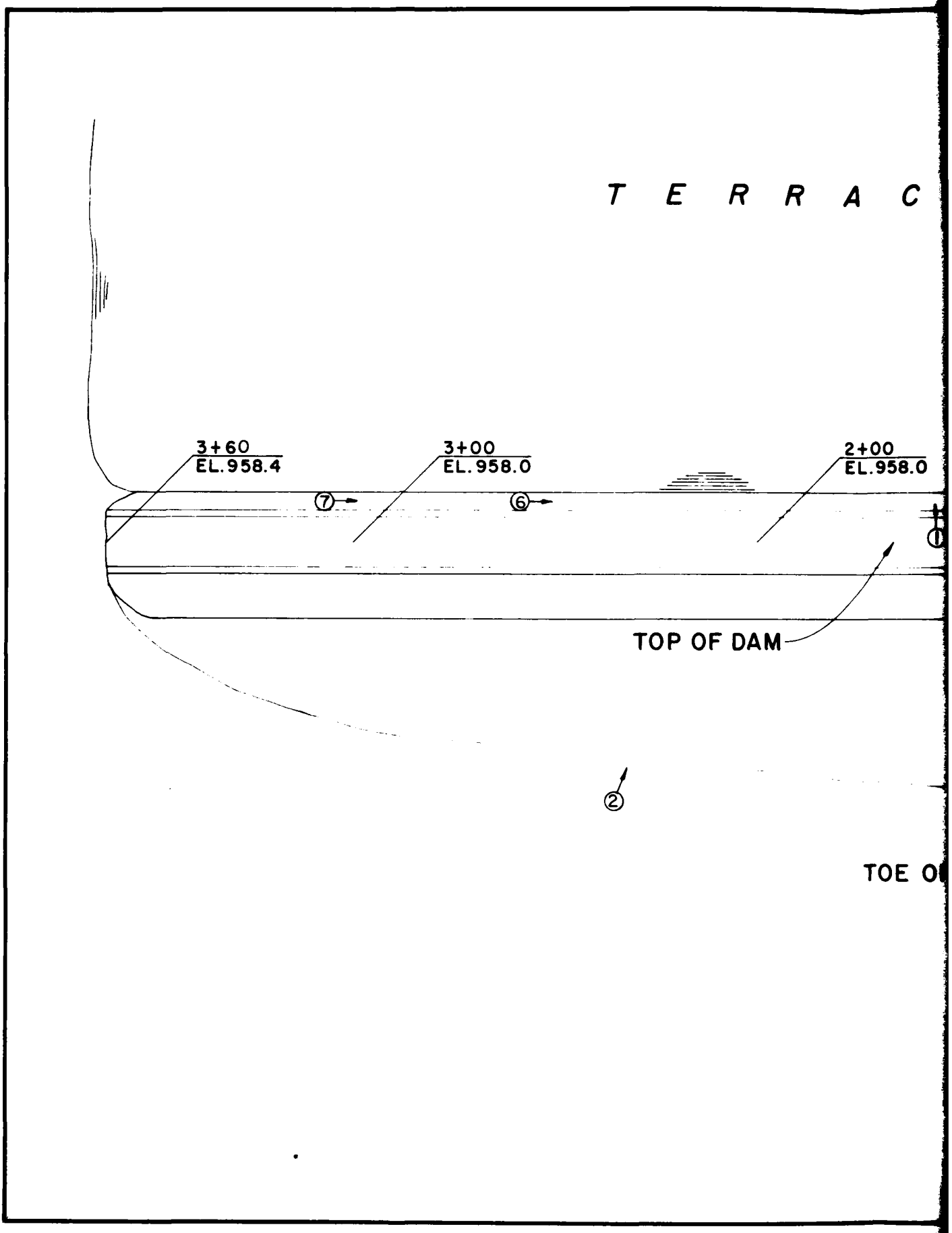
PLATE 2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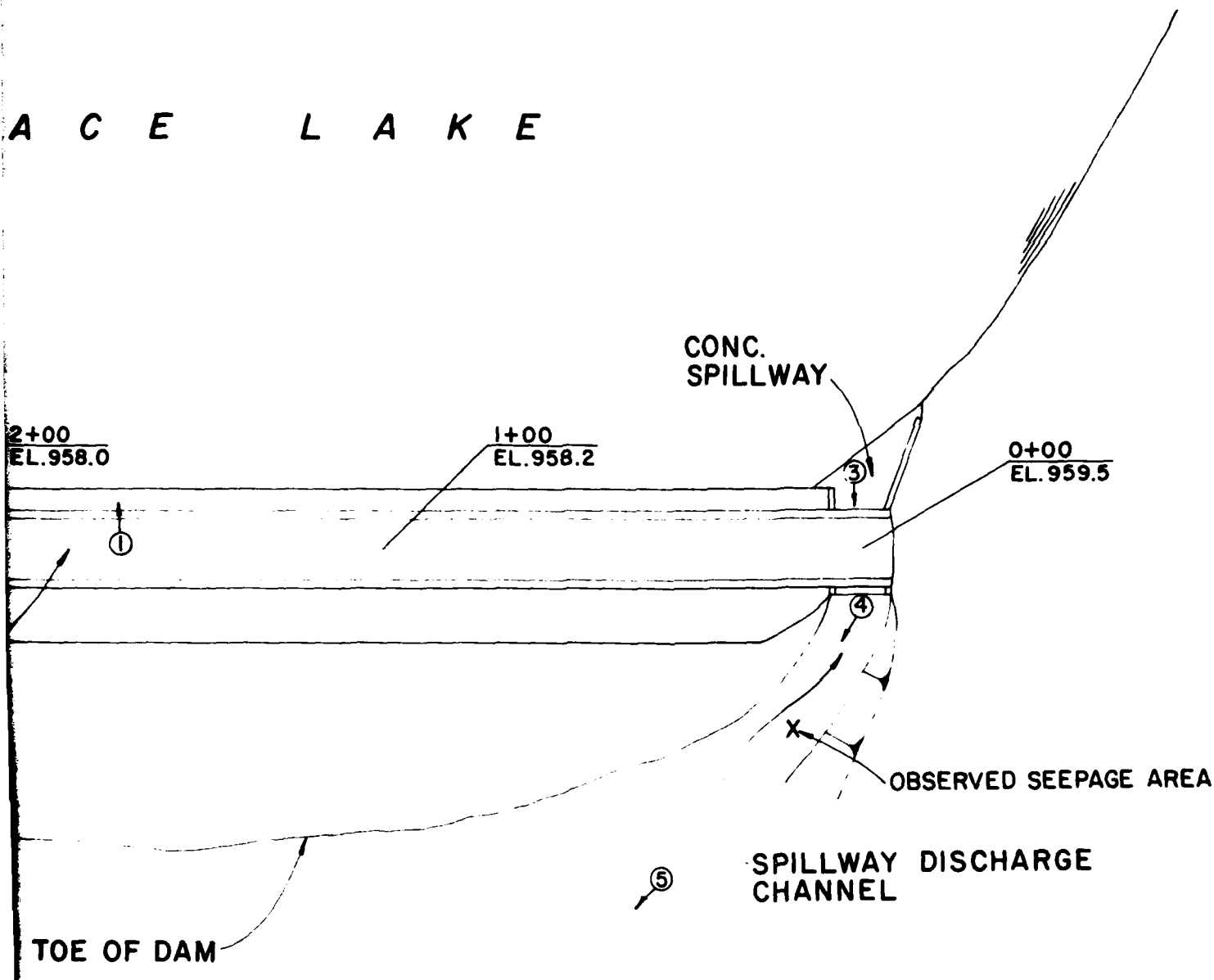
TOP OF DAM
②
TOE O



GRAPHIC SCALE

1 30

10 0 10 20 30 40

N

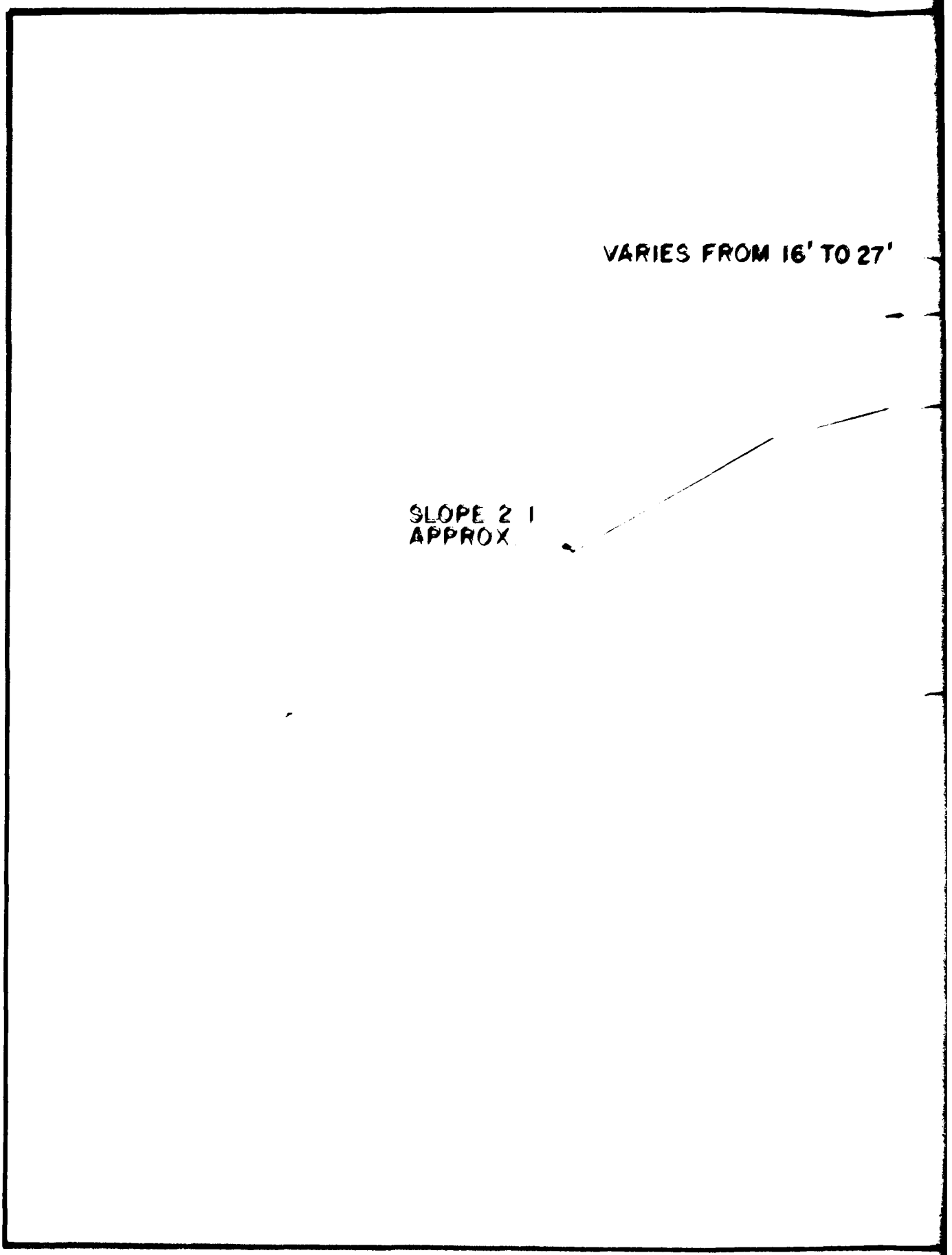
① PHOTOGRAPH LOCATION AND DIRECTION

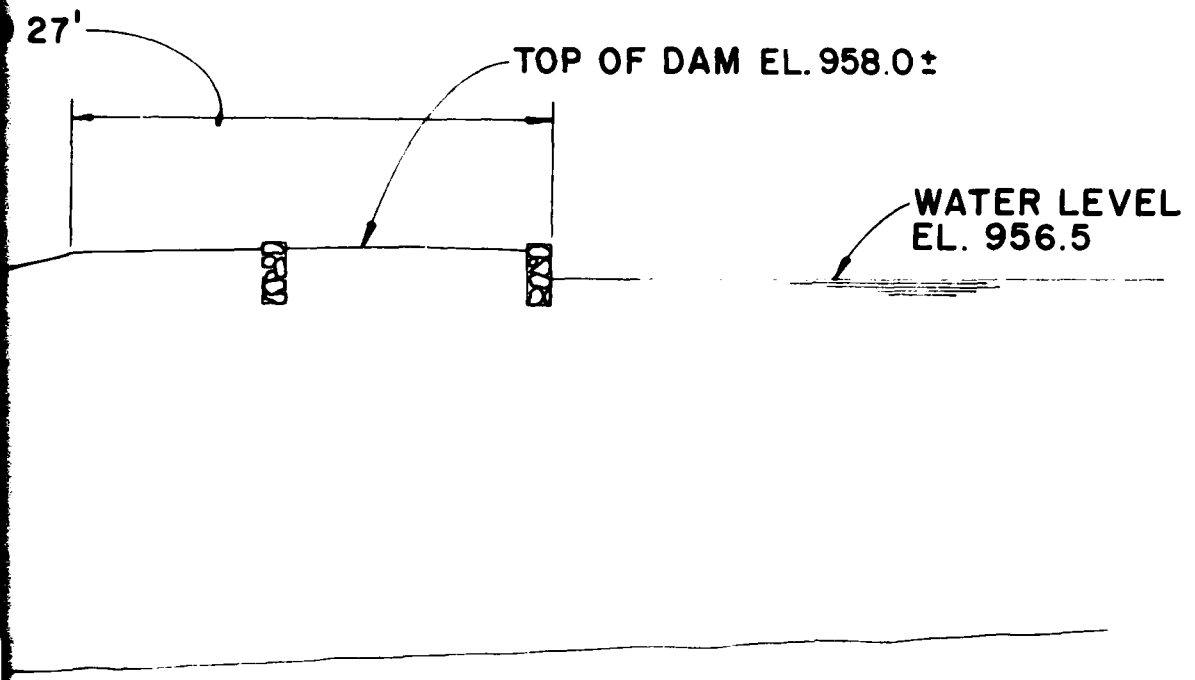
TERRACE LAKE
PLAN

PLATE 3

1

2

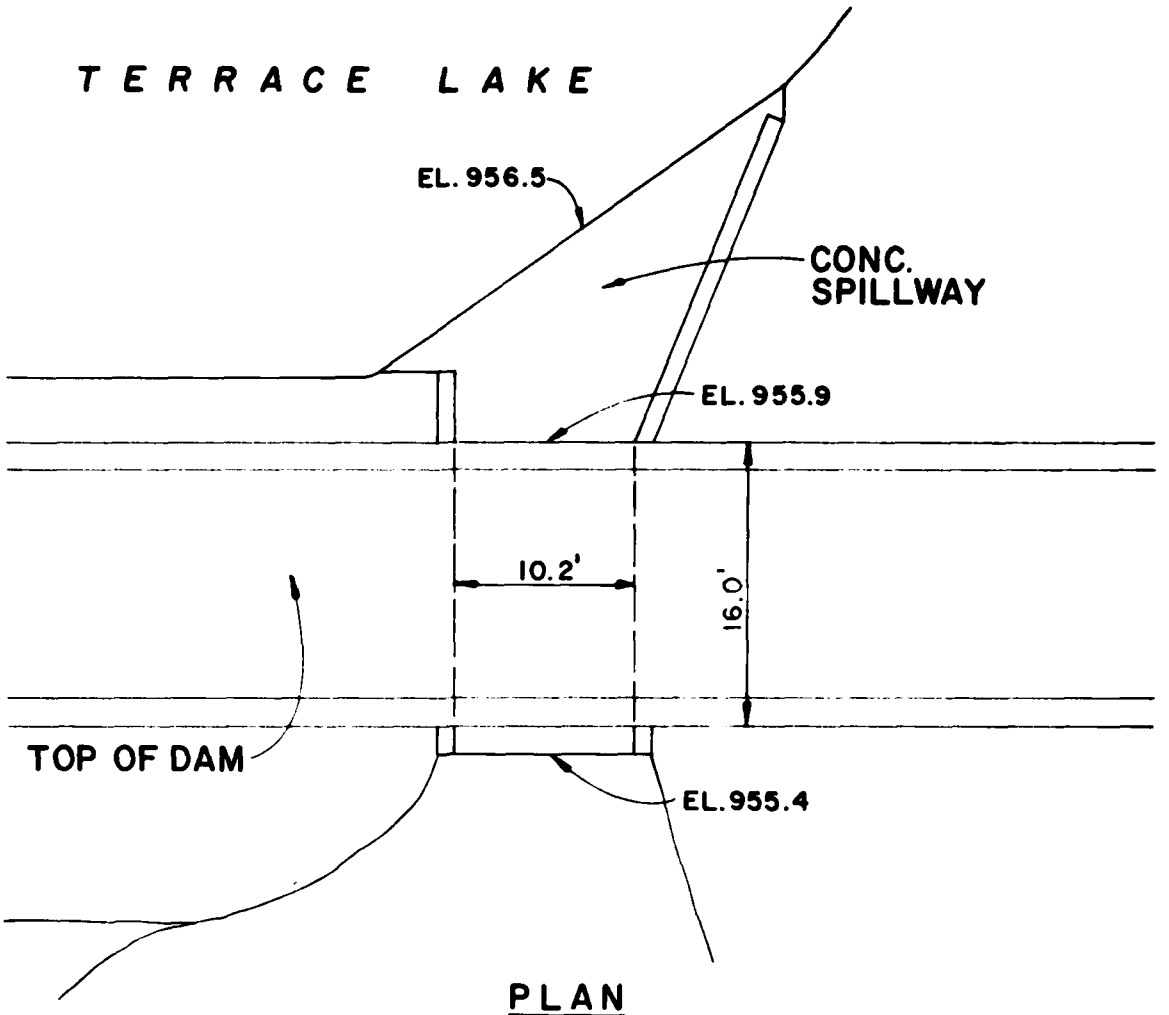

VARIES FROM 16' TO 27'
SLOPE 2 1
APPROX



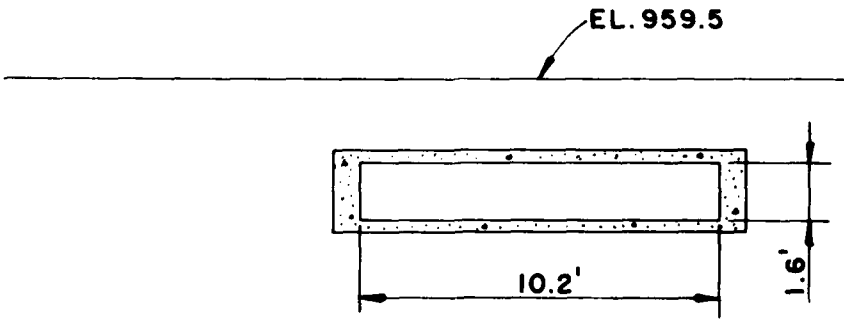
NOT TO SCALE

TERRACE LAKE
TYPICAL SECTION

PLATE 4



PLAN



SECTION

TERRACE LAKE
SPILLWAY

PLATE 5

PHOTO 1 OVERVIEW OF LAKE

PHOTO 2 TOE OF DOWNSTREAM SLOPE
(LOOKING UPSTREAM)

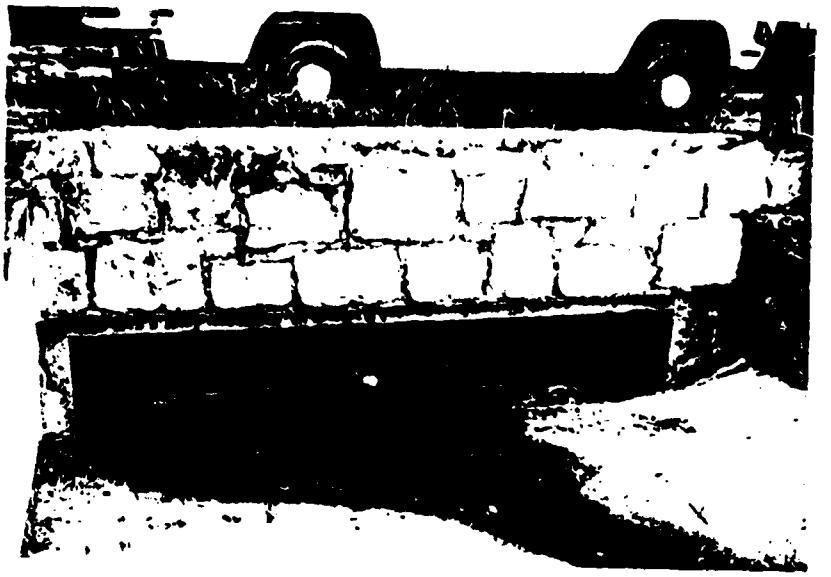


PHOTO 3 SPILLWAY (LOOKING DOWNSTREAM)

PHOTO 4 DISCHARGE CHANNEL
IMMEDIATELY DOWNSTREAM OF SPILLWAY
(LOOKING DOWNSTREAM)

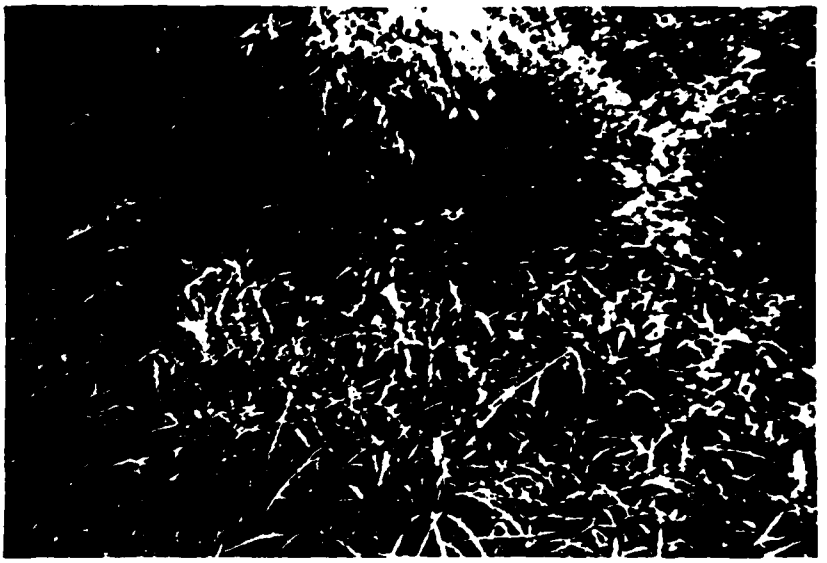


PHOTO 5 DISCHARGE CHANNEL
(LOOKING DOWNSTREAM)

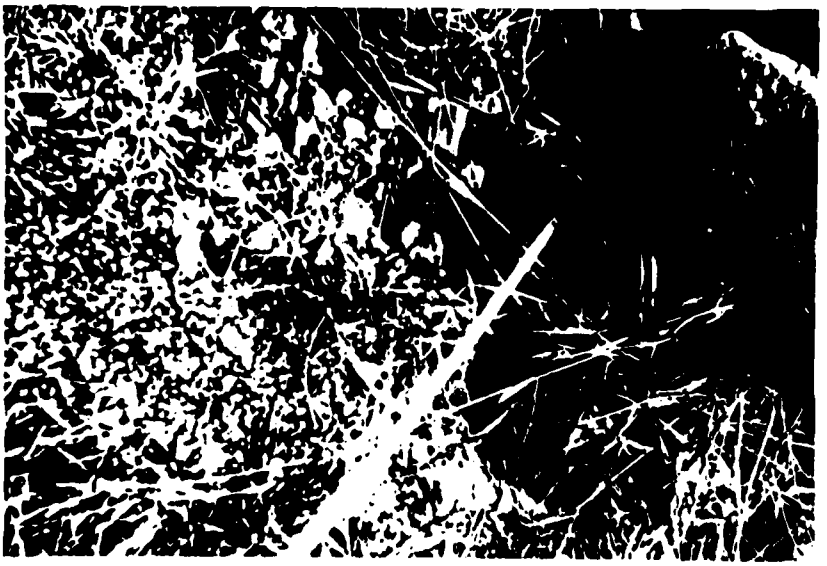


PHOTO 6 EROSION ON UPSTREAM SLOPE

PHOTO 7 EROSION ON UPSTREAM SLOPE

APPENDIX A

HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1_1 were used to develop the inflow hydrograph (see Plate A-1) and hydrologic inputs are as follows:

a. Twenty-four hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33:

200 square mile, 24 hour rainfall	- 24.8 inches
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile rainfall	- 130%

b. Drainage area = 8,700 acres.

c. Time of concentration (Tc) = $(11.9 \times L^3/H)^{0.385}$ = 11 minutes (L = length of longest watercourse in miles, H = elevation difference in feet)$_2$

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 82 and antecedent moisture condition III.

2. Spillway discharge rates and flows over the top of dam are based on the broadcrested weir equation:

$Q = CLH^{1.5}$
C = varies from 2.70 to 2.63 (for both the spillway and the dam)
L = 10.2 feet (length of weir for the spillway) 362 to 400 feet (length of weir for the dam)
H = head on weir

and the equation for determining pressure flow in culverts

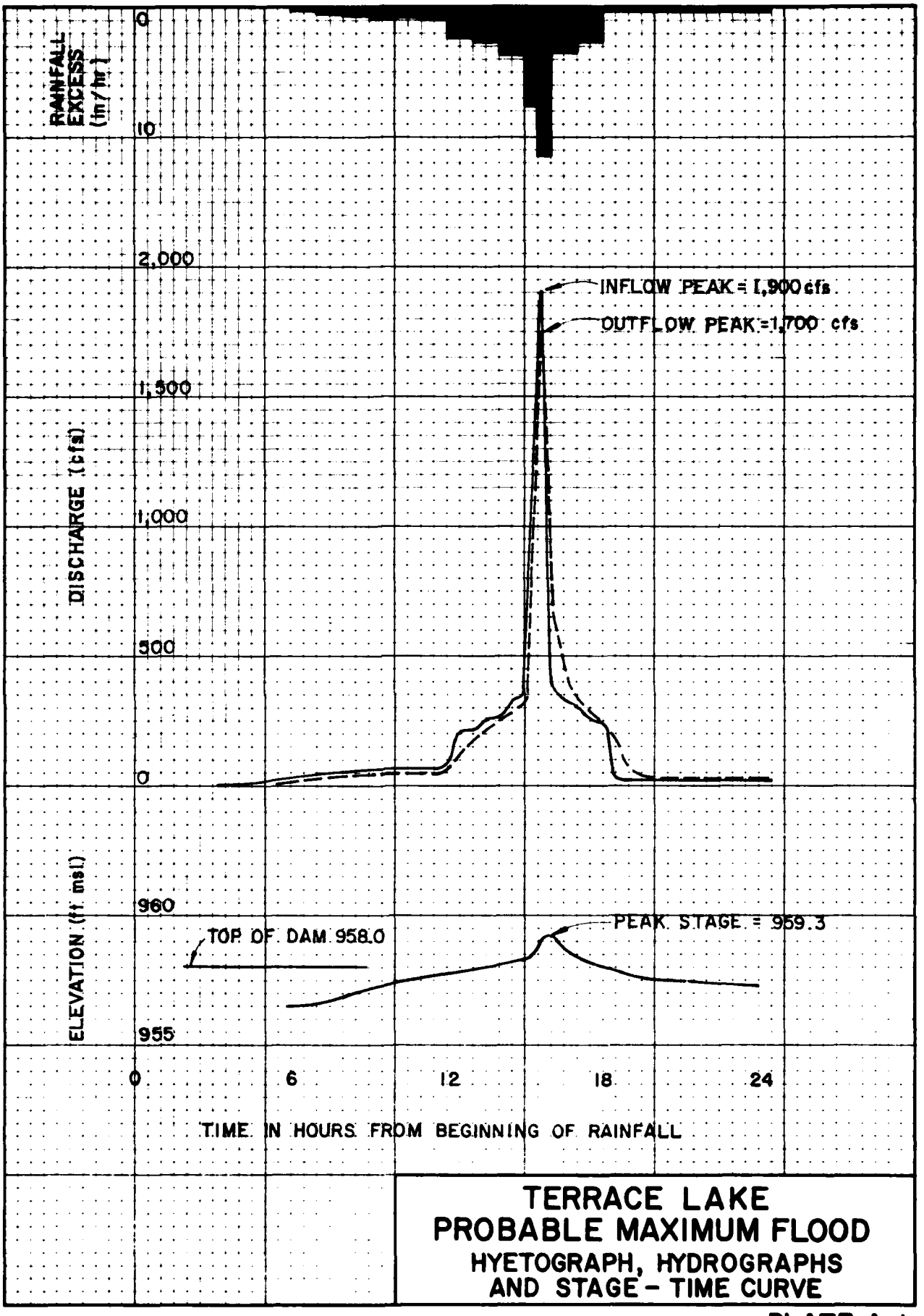
$Q = Ca(2gh)^{0.5}$
C = 0.83
a = 16.32 sq_2ft (waterway area of culvert)
g = 32.2 fps^2
h = difference between the upstream and downstream heads

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. The storage between two elevations was computed by multiplying the average of the areas at the two elevations by the elevation difference. The summation of these increments below a given elevation is the storage below that level.

4. Floods are routed through the spillway using HEC-1, modified Puls to determine the capability of the spillway. Inflow and outflow hydrographs are shown on Plates A-1, A-2, and A-3.

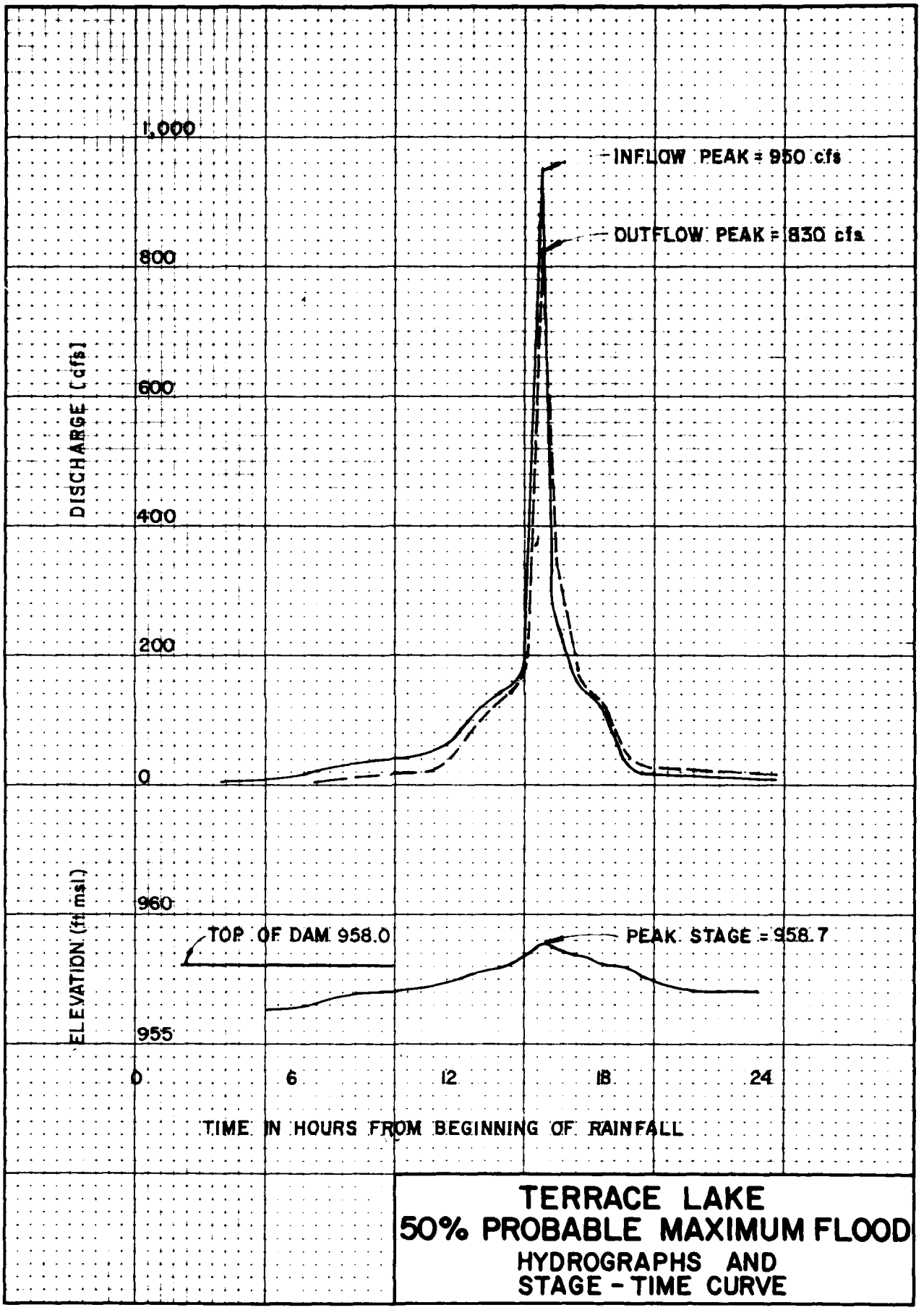
1. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July, 1978, Davis, California

2. U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.



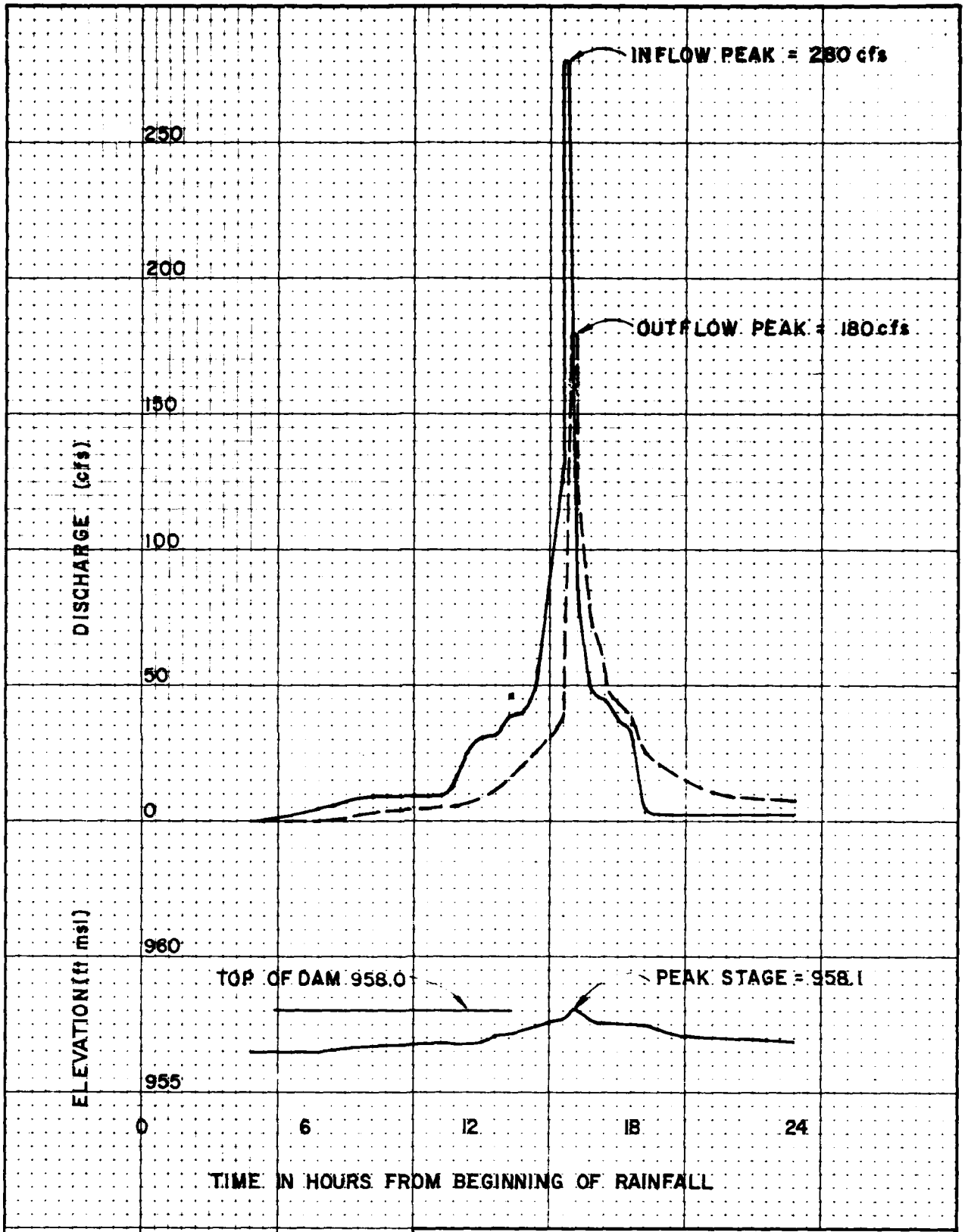
TERRACE LAKE
PROBABLE MAXIMUM FLOOD
HYETOGRAPH, HYDROGRAPHS AND STAGE - TIME CURVE

PLATE A-1



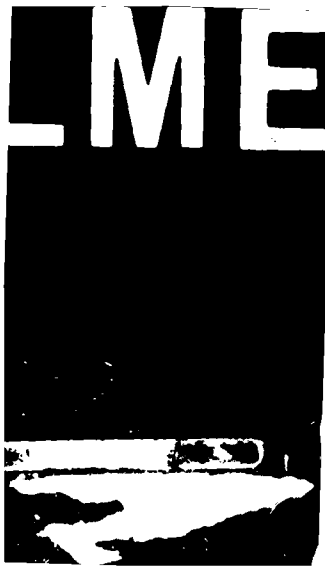
TERRACE LAKE
50% PROBABLE MAXIMUM FLOOD
HYDROGRAPHS AND STAGE - TIME CURVE

PLATE A-2



TERRACE LAKE
15 % PROBABLE MAXIMUM FLOOD
HYDROGRAPHS AND STAGE - TIME CURVE

PLATE A-3


LME